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Revisión | Review

Review of the situation of *Hedeoma multiflora* Benth. (Peperina de las Lomas): an aromatic-medicinal Argentine species at risk

[Revisión de la situación de *Hedeoma multiflora* Benth. (Peperina de las Lomas): especie aromática medicinal Argentina en riesgo]

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Abstract: Aromatic and medicinal plants (AMPs) have great potential for the synthesis of secondary metabolites, which are used by the pharmaceutical and food industry. In addition, they are part of ancestral medicine and the livelihood of many families in regional economies. Argentina has a high number of AMPs. However, the intensive extraction system (overexploitation), together with other anthropic actions, puts them at risk. The "peperina de las lomas" (*Hedeoma multiflora* Benth. (Lamiaceae)) is within this problem. This native species, xerophyte, is distributed in central Argentina, in stony mountain areas, forming small bushes. In this work, the existing information of the species was collected, covering from its environmental problems to the most recent investigations, oriented towards its conservation and the development of its germplasm. These data will serve to promote activities aimed at preventing the degradation of this resource and promoting its sustainable use.

Keywords: Aromatic-medicinal plants; Sustainable development; Essential oils.

Resumen: Las plantas aromáticas y medicinales (PAMs) tienen un gran potencial para la síntesis de metabolitos secundarios, los cuales son utilizados por la industria farmacéutica y alimentaria. Además, son parte de la medicina ancestral y el sustento de muchas familias de las economías regionales. Argentina posee un alto número de PAMs. Sin embargo, el sistema de extracción intensivo (sobreexplotación), junto a otras acciones antrópicas, las coloca en riesgo. La “peperina de las lomas” (*Hedeoma multiflora* Benth. (Lamiaceae)) se encuentra dentro de esta problemática. Esta especie nativa, xerófita, se distribuye en el centro de Argentina, en zonas pedregosas serranas, formando pequeñas matas. En este trabajo se recopiló la información existente de la especie abarcando, desde su problemática ambiental hasta las investigaciones más recientes, orientadas a su conservación y al desarrollo de su germoplasma. Estos datos servirán para promover actividades destinadas a evitar la degradación de este recurso y propiciar su aprovechamiento sustentable.

Palabras clave: Planta aromática-medicinal; Desarrollo sostenible; Aceites esenciales.

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INTRODUCTION

Aromatic-medicinal plants (AMPs) are an important reservoir of secondary metabolites and potentially useful genes for man. That is why the conservation and multiplication of native plant species becomes increasingly important and opens opportunities for the improvement of these resources. Currently, there is an increase in the interest of the population to know the origin, quality and composition of the products they consume. At the same time, there is an increase in the demand for natural products, a fact that causes industries such as pharmaceutical, food and cosmetic, try to incorporate natural products instead of synthetic products.

Hedeoma multiflora is a native and wild species that, like other AMPs, is in a critical situation due to overexploitation and deterioration of its natural environment. To the ecological problems is added the limited knowledge about the biology of this species and its secondary metabolites, necessary to develop a domestication program, standardize the quality of the product or find new applications.

Considerations

The revised databases were SciELO, PubMed, ScienceDirect and Google Scholar, considering studies between 1961 and 2019, searching for terms like *Hedeoma multiflora* and *Hedeoma multiflorum*. Articles written in English and Spanish were included in the search.

Vernacular Names

Hedeoma multiflora is popularly known as tomillo, menta del campo, peperina de las lomas, peperina puntana, peperina de la sierra, tomillo serrano, tomillo del campo, cominito del campo, mastuerzo, hierba del pájaro (Elechosa *et al.*, 2009) and tomillito de la sierra (Ordóñez *et al.*, 2006).

Synonyms

According to Flora Vascular de la República Argentina (Anton and Zuloaga, 2018), Catalog of vascular plants of South Cone (http://www.darwin.edu.ar) and The Plan List (http://www.theplantlist.org), the main accepted synonyms are:

Satureja gilliesii (Benth.) Briq., in Nat. Pflanzanf 4 (3a): 300 1897.
Satureja bonariensis (Fisch. & C.A.Mey.) Briq., in Nat. Pflanzenfam. 4 (3a): 300 1896.
Clinopodium bonariense (Fisch. & C.A.Mey.) Kuntze, in Revis. Gen. Pl. 2: 515 1891.
Gardoquia racemosa (Spreng. ex J.A.Schmidt), in Fl. Bras. 8: 170 1858.
Micromeria bonariensis (Ten.) Fisch. & C.A.Mey, in Index Seminum (LE) 10: 56 1845.
Thymus bonariensis (Ten), in Index Seminum (NAP) 1839 (ad.): 2 1839.
Hedeoma multiflora (Benth.), in Labiat. Gen. Spec. 367 1834.
Hedeoma gilliesii (Benth.), in Labiat. Gen. Spec. 367 1834.

Related species

The genus *Hedeoma* is a group of annual or perennial plants, found throughout the Americas. Four species have been documented for South America: *H. multiflora* in central Argentina, in Rio Grande do Sul (Brazil) and in the department of Paysandú (Uruguay); *H. medium* in Entre Ríos and Buenos Aires (Argentina) and in Paysandú and Soriano (Uruguay); *H. mandoniana* in the Northwest of Argentina, and *H. polygalifolia* in Rio Grande do Sul (Brazil) (Irving, 1980). Recently, Keller & Tressens, (2016) have described a fifth species, *H. teyucuarensis*, endemic to the province of Misiones in Argentina. A dichotomous key of the named species is shown in Figure No. 1.

Clave de las especies de *Hedeoma* presentes en el Cono Sur de América del Sur

1. Plantas de hasta 60 cm alt. Hojas de 15-35 x 5-13 mm. Inflorescencias axilares 3-20 floras .... *H. teyucuarensis*
1. Plantas de hasta 30 cm alt. Hojas de 5-17 x 1-7 mm. Inflorescencias axilares 1-6 floras 2
2(1'). Hojas ovadas, obovadas o elípticas; margen crenado en la mitad superior. .... *H. mandoniana*
2. Hojas linear lanceoladas, linear elípticas, oblanceoladas u oblongas; margen entero 3
3(2'). Hierbas hasta de 10 cm alt., no cespitosas; tallos decumbentes con nudos enraizantes. Inflorescencias axilares 1-3 floras. Clusas esferoidales, superficie areolada .... *H. polygalifolia*
3. Hierbas hasta de 30 cm alt., cespitosas; tallos ascendentes. Inflorescencias axilares 1-6 floras. Clusas oblongas, superficie foveolada 4
4. Cáliz de 5-7 mm. Corola de 7-11 mm .... *H. multiflora*
4. Cáliz de 4,2-5 mm. Corola de 4-8 mm .... *H. medium*

Figure No. 1
Key to the Hedeoma species of the region. (Taken from Keller & Tressens, 2016)

Geographic distribution and ecology

Hedeoma multiflora is distributed in Argentina, Uruguay and Brazil. Within Argentina, it was reported by Fester *et al*. (1961) in Buenos Aires, Mendoza, Catamarca, Entre Ríos, Córdoba, La Pampa, Río Negro, Santiago del Estero and San Luis. Inhabits dry, stony hills and mountain environments, up to 1000 meters above sea level (Elechosa *et al.*, 2009). It has been described in three protected areas: Quebrada del Condorito National Park (Córdoba), Lihue Calel National Park (La Pampa) (Mazzola *et al.*, 2008; Prina *et al.*, 2015) and in El Palmar (Entre Ríos) (Cusato & Pilberg, 1997).

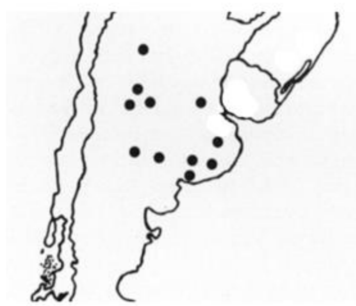

Figure No. 2: Distribution of *Hedeoma multiflora* in the Argentine territory (Adapted from Irving, 1980)

Commercial uses

Aromatic plants are those that produce, mainly, essential oils (EOs), complex mixtures of volatile compounds that confer characteristic fragrance. While, medicinal plants are those that produce secondary metabolites that exert a pharmacological action on an organism (Muñoz López de Bustamante, 1996).

The most important use of *H. multiflora* is related to the food industry, in particular that of beverages and infusions. In this sense it is used in the preparation of alcoholic beverages and snacks prepared based on bitter herbs (Lagrotteria & Lozada, 1993). In the same way, it is also required for its water-soluble components to be used in flavored waters with functional properties (García Luján *et al.*, 2010). On the other hand, the herbs use it as a flavoring in the so-called "yerbas compuestas" (Bocco *et al*., 1993; Martínez, 2005).

In folk medicine *H. multiflora* is used as an infusion to treat abdominal and stomach conditions such as gastritis (Goleniowski *et al.*, 2006). It acts as anti ulcer and anti hemorrhoidal (Lagrotteria & Lozada, 1993; Menseguez *et al*., 2007; Luján & Martínez, 2017; Luján & Martínez, 2019; Luján *et al.*, 2017).

Morphological characterization

Hedeoma multiflora is a small plant with multiple stems and woody roots, and its growth is confined to restrictive environmental conditions. It is xerophytic, perennial and very aromatic, with a smell similar to the "peperina" in bloom. It develops forming small bushes wich ar approximately 10 to 15 cm high, whose stems and leaves contain the essential oil (Figure No. 3a). The flowers are numerous 7-11 mm long, arranged in the armpits with pedicels of 2 to 4 mm, usually bluish or lilac (Figure No. 3b). The leaves are linear-lanceolate 5 to 6 mm long, with whole margins, very thick cuticle and deciduous (Figure No. 3c) (Irving, 1980). They have abundant simple trichomes, uni or bicellular, verrucous, with spherochrystals in the basal cell, and glandular hairs pelted with 10 cells of which 8 are secretors of the oils (Figure 4 a). In addition, it presents glandular hairs, with a single-celled head, mucilage secretors (Figure 4b) (Bonzani & Ariza Espinar, 1992).

Figure No. 3
General appearance of the adult plant (a). Detail of the flowers (b). Appearance of the leaves (c) [Photos: Patricia Peralta]

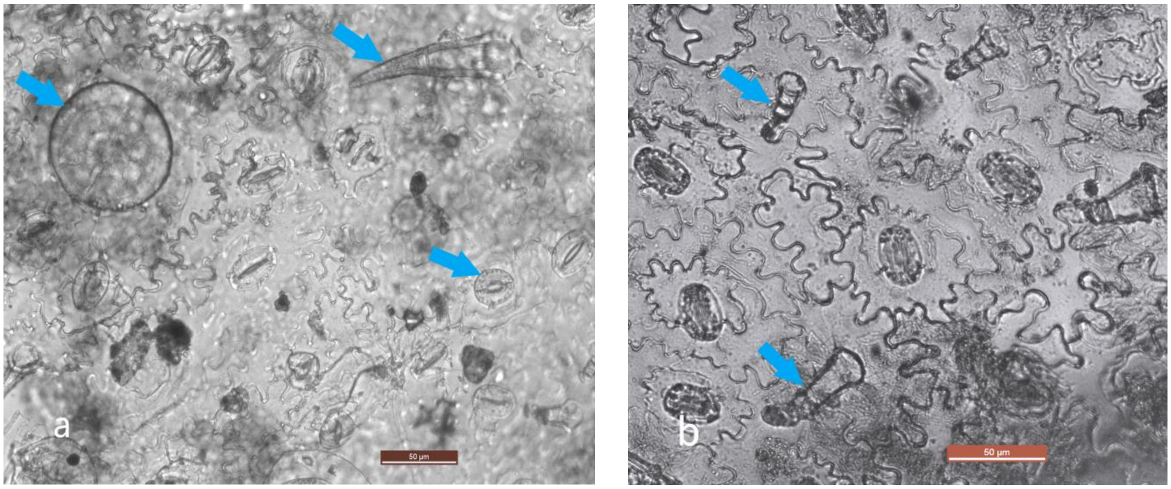

Figure No. 4
Detail of abaxial epidermis, from left to right: glandular trichome, pelted glandular hair and diacytic stomata (a). Glandular hairs with mucilage secretory head (b)
[Photos: Patricia Peralta]

The fruits are dry and indehiscent (Figure No. 5a), the oblong clusts barely trigone, in groups of three per fruit, 1.2 - 1.5 mm long and 0.3 to 0.8 mm wide (Farías, 1994; Terenti Romero *et al.*, 2016). Smooth brown pericarp (Figure No. 5b), the basal thread (0.15 ± 0.02 mm) and the thickness of the tegument (0.049 ± 0.003 mm). It presents a reaction of myxocarpal with continuous, transparent mucilage and with a strong reaction (0.5 ± 0.14 mm). The embryo is spatulated axillary, without endosperm.

Figure No. 5
Fruits (a) and detail of the seeds (b). Myxocarpal reaction (c).
[Photos: Patricia Peralta]

Cytogenetic Characterization

The chromosomal number of this genus is based on an x = 18. *Hedeoma multiflora* is a 2n = 72 species, which would suggest a 4x ploidy level (Irving, 1980). Liébana *et al*. (2017) detected instability and abnormalities during meiosis, such as cells with variations in the chromosomal number in the same individual (mosaic), presence of univalents, cytomixis, delayed chromosomes in anaphase I with the consequent formation of micronuclei.

Chemical composition

Table No. 1 details the reports of different authors indicating that the species has a high degree of homogeneity in the chemical composition of its EOs, the main components being: pulegone, mentone and isomentone. This would indicate that it is a single specific and stable chemotype, at least in the locations evaluated (Montes, 1961; Fester *et al*., 1961; van Baren *et al.*, 2010; Juárez *et al.*, 2018). However, it is also observed that the percentages of these components may vary depending on the time of the year, the physiological state of the plant, the climate and the age of the plant.

The minor compounds are α-Pinene, β-Pinene, Myrcene, Limonene, cisIsopulegone, α-Copaene, Germacrene-D, Germacrene-A. (Fester *et al*., 1961; Koroch *et al.*, 1999; Vazquez *et al.*, 2007).

Table No. 1
Percentages of the three major components present in the essential oil of *H. multiflora*, according to the author

% Pulegone	% Mentone	% Isomentone	Province	References
62,1	14,1	8,9	San Luis 1 population	Koroch (1999)
50,7	36	2,23	Córdoba 1 population	Vazquez (2007)
December 39,4 March 89,0	December 2,9 March 28,5	December 5,1 March 37, 7	San Luis 5 populations	Fernández (2007)
December 88,6 March 14,6	December 30,2 March 2,5	December 37 March 3,9	San Luis 7 populations	van Baren (2010)
63,76	25,83	2,24	Córdoba *In vitro*	Diaz *et al.*, (2010)

The yields of essential oil vary according to the phenological state of the plant and these oscillations can occur between 2.69% and 3.89% (Fernández *et al.*, 2007), between 1.18% and 5.43% (van Baren *et al.*, 2010) and 1.90% (Koroch *et al.*, 1999), being higher in the collections of December with respect to the collection in March, coinciding with the beginning of flowering.

On the other hand, in the non-volatile fraction, Dadé *et al.*, (2009) reported the presence of phenols and flavonoids. These compounds would have as main function to protect the plant against oxidation that occurs during photosynthesis and also against the attack of herbivores.

Pharmacological actions and biological activity

Some researchers have conducted studies aimed at corroborating the uses in folk medicine and evaluating the pharmacological action of the extracts. In this sense, Garro *et al.*, (2006), in lab tests with rats, they verified the protective effect of the aqueous extract on the gastrointestinal tract on the damage caused by ethanol. On the other hand, Dadé *et al.* (2009) studied the antioxidant activity of aqueous extracts of *H. multiflora* and reported a very high capacity for inhibition of lipid peroxidation of human plasma induced by Cu^{2+}. These same authors determined that the high content of phenols and flavonoids would be responsible for such activity. Similarly, these compounds confer cytotoxic activity on polymorphonuclear cells by triggering the apoptotic process in transfused or malignized cells (Dadé *et al.*, 2011).

In this context, it is important to highlight that, although *H. multiflora*, is used in folk medicine for different conditions, and which its therapeutic action is demonstrated, this species has not yet been registered in the Argentine Pharmacopoeia (Farmacopea Argentina Septima edición, 2013).

On the other hand, Palacios *et al.* (2009) and Bertoni (2013) evaluated the insecticidal activity of essential oils (EOs) of *H. multiflora* against adults of *Musca domestica* and found very potent neurotoxic effects in the short term. While Flores (2018) studied the effect of terpenes present in its essential oils on *Aedes aegypti* and observed a dose-dependent adulticidal response, with pulegone being the most toxic compound.

Propagation

The domestication of a plant species demands, as a first requirement, to know the different possibilities for its propagation in order to establish, in the future, possible strategies for its cultivation and improvement.

Sexual propagation and cultivation

Suárez *et al*. (2000) conducted field trials of *H. multiflora* using a material from La Cumbre (Córdoba). It recorded a germination of 72% in a laboratory test.

The seedlings were potted with a mixture of 50% mulch and 50% black soil as a substrate. After 90 days the seedlings were taken to the field and a low percentage of roots was recorded (37%). The authors recommended trying alternative substrates. In another study, a group of small producers of aromatic and medicinal herbs from Traslasierra, Córdoba, was able to develop a growing calendar based on local experience. The recommended date for sowing is in September (Suarez, 2003; Fernández *et al.*, 2006).

In addition, Martínez and Fernández (2000) evaluated groups of seeds collected over three consecutive years in San Luis, and determined that there are differences in germination power (GP), depending on their storage time. A low percentage was recorded in freshly harvested seeds and a peak in germination at six months of harvest. This result would indicate that the seeds have a sleeping state that must be overcome to obtain a good GP. When they exceed the year of age, this parameter is kept low. The same conclusions reached Fernández *et al.* (2006) when evaluating germination under laboratory conditions, where the primary rest period was exceeded after six months after harvest, reaching a GP of 91%. On the other hand, Lartigue *et al.* (2016) compared two populations; one of them presented an average GP of 7% and the other population of 76%. Given this discrepancy in the results, the authors conducted a test with tetrazolium in the seeds, and confirmed germination levels, which coincides with the variability in both populations, so studies should be continued to determine the causes of these differences.

Other researchers evaluated germination under *in vitro* conditions. The GP obtained by Terenti Romero *et al*. (2016) was 24 and 26% in MS medium diluted to 25% (Murashige & Skoog, 1981) and half WPM medium (Lloyd & McCown, 1981), respectively.

Next, in Table No. 2, the works of different authors related to the harvest and germination of the seeds are summarized:

Table No. 2
Percentage of germinated seeds, evaluated at different days and with different management, according to different authors

Storage time	% GP	Province	Conditions	References
Naked seed At 7 days At 18 days Seeds without threshing At 7 days At 27 days	Naked seed 39 72 Seeds without threshing 5 35	Córdoba	Harvest in February. Photoperiod 8/16. Temperature alternation 30ºC/20ºC.	Suarez *et al.*, 2000
Freshly harvested: 6 months 1 year 2 years 3 years 4 years	15 91 82 87 74 76	San Luis	Manually threshed. Natural light. 25 ± 2 ºC	Martínez & Fernández, 2000
At 11 days	37	Córdoba	Cosecha en febrero. Fotoperíodo 8/16. Alternancia de temperatura 30ºC/20ºC. Cold pretreatment for 5 days	Rolando *et al.*, 2004
At 7 days	4 a 24	San Luis	*In vitro* MS 25%	Terenti *et al.*, 2016

With respect to culture trials, in San Luis, Martínez *et al*., (2000) sowed in experimental plots. They reported that the cultivated plants averaged 23.5 cm in height at the end of the year, showing an average productivity of 1430 g of fresh matter/m^2 and 17.46% of dry matter. These plants fulfilled an annual cycle, while, in natural conditions, the wild ones present a perennial life cycle. This difference in behavior could be explained by the effect of resource competition due to high implantation density or fungal proliferation. Similar results obtained Fernández *et al.* (2006) when sowing seeds of wild plants with more than six months old seeds, with a GP greater than 90%. They were covered with a thin layer of mulch and sprinkled. The development of the plants, at the beginning, was greater than the wild ones and presented an annual behavior.

On the other hand, Peralta *et al.* (2018a) evaluated 90-day acclimatization *ex vitro* plants in Buenos Aires. Manual weeding and irrigation were performed according to requirements. All plants adapted to the environment (100% survival). During the vegetative period the diameter of the bush increased and the height decreased, showing stems of decumbent habit. Two months after implantation, all individuals originated seeds by presenting a bi-annual cycle.

Asexual spread (Macro and micropropagation)

Hedeoma multiflora has been propagated both *in vivo* (macropropagation) and *in vitro* (micropropagation). The first case is the process by which the rooting of branches or shoots is induced to obtain new plants with the same characteristics, genetics and quality as the mother plant. In the second case, through the application of tissue culture techniques, clones are also obtained, but with a higher multiplication rate, in less space and in more limited periods.

With regard to macropropagation, Fernández *et al.* (2006) conducted an experiment with juvenile herbaceous cuttings, approximately 8 cm in length and without the addition of rooting promoters. 86% of rooted plants were obtained that could be transferred to the field. Subsequently, they performed another experiment with mature herbaceous cuttings (from the basal and apical part) treated with the growth regulator naphthalene acetic acid (NAA). The rooting percentages were higher in the apical segments (84%) in the control material, without differences between the cuttings treated.

Besides, micropropagation was evaluated by several researchers using different culture media, dilutions and concentrations of growth regulators.

Brunetti *et al.* (2007) and Pedranzani *et al.* (2002) reported greater elongation of the main axis in the *in vitro* establishment and a high percentage in survival, when using half-diluted MS medium and regardless of the concentration of 6, benzylaminopurine (BAP).

With the purpose of evaluate the bud multiplication rate and generation of roots in this species, different authors performed tests in MS medium (complete and at half concentration) supplemented with NAA and BAP as growth regulators. The results are within a range of 7 to 32 shoots and 4 to 17 roots per vitroplant (Koroch *et al.*, 1997; Peralta *et al.*, 2016, 2017; Díaz *et al.*, 2018).

Koroch *et al.* (1997) demonstrated that the concentration of sucrose in the culture medium, while increasing the number of roots and decreasing their length, does not affect (or improve) the acclimatization of the seedlings.

Regarding the size of the explant, Pedranzani *et al.* (2002) reported that, from uninodal explants, vigorous plants, without chlorosis, were achieved at a temperature of 20 ± 2 ° C, with an average length of 10 cm in height. In addition, the authors suggest for acclimatization to use as a substrate a mixture of sterile vermiculite and organic soil (1: 1), cover the pots with polyethylene bags and evaluate at least one month.

Finally, in order to evaluate the effect of the cultivation conditions on the production of essential oils of *H. multiflora*, Díaz *et al.* (2010) they tested different base media: SH (Schenk & Hildebrandt, 1972), WPM and B5 (Gamborg *et al.*, 1968) and different combinations of NAA and BAP. The authors found no differences in the qualitative and quantitative composition of EOs in plants from culture media with different nutrient concentrations or regulators.

Generation of new germplasm

As already described for other AMPs, the combination of polyploidization through mitosis inhibiting agents and *in vitro* tissue culture, are tools through which it is possible to increase the production of active ingredients (Salma *et al.*, 2017). In this context, Peralta *et al.* (2018b), cultured clones *in vitro* on MS medium supplemented with 2.2 μM of BAP, which were then transferred to the same medium plus the colchicine aggregate (0.01% P/V). They obtained 52% of individuals who presented an increase in the content of their genetic material, but not all of them passed the acclimatization stage. *Hedeoma multiflora* could be considered a candidate to start trials that increase its value through these techniques, facilitating the process of introduction to the crop and its domestication.

Molecular markers

Molecular markers are a biotechnological tool that allows to detect variability and perform a genetic characterization of individuals and natural populations. In this way they are useful for breeding programs and germplasm banks. Likewise, they allow corroborate the genetic stability of plants multiplied *in vitro*. Díaz *et al*. (2011) optimized the AFLP technique to analyze samples collected from two natural populations of *H. multiflora* from the Córdoba hills and samples from *in vitro* culture. The band patterns obtained showed a high degree of polymorphism in natural populations, but not in *in vitro* specimens.

Environmental problem of Hedeoma multiflora

The increase in demand by industry and the detriment of the economy has led to a raise in the number of people engaged in the extraction of wild AMPs (Barboza *et al.*, 2009). Many times, these are vulnerable species, increasing the threat to natural populations and the ecological impact caused by this activity. In general, plant species collected from the natural environment are commercialized in a nonsustainable way, without controls by government entities, jeopardizing the functioning of these ecosystems. For example, Fernández *et al.* (2006) refer to *H. multiflora* being sold in bundles of about 50 to 60 whole plants.

Although the overexploitation of these species could be analyzed from different approaches, the degradation of native genetic resources (gene erosion, loss of potential crops and negative socioeconomic impact, to name a few) is what is shown as the most relevant. Likewise, the marked decrease in vegetation cover increases runoff and erosion of soils with greater slope. In addition, animals experience disturbances in the habitat, a decrease in food resources and also in the number of areas suitable for shelter (Fernández *et al.*, 2006; Elechosa *et al.*, 2009).

The peperina de las lomas is a species considered of low demand. However, for years, collectors find it difficult to collect a sufficient volume for sale (Fester, 1961 and Montes, 1964). This problem, far from being overcome, persists over time (Lagrotteria & Lozada, 1993; Fernández *et al.*, 2006; Goleniowski *et al.*, 2006; Elechosa *et al.*, 2009; Peralta *et al.*, 2016).

It is important to highlight that it was not possible to find official regional reports on the supply and demand of this species. There are only some works carried out based on surveys of collectors and users (Bocco *et al.*, 1993; Luján & Martínez, 2017). Currently, there is no data on its cultivation, but trials are being developed for its introduction to the field.

DISCUSSION AND CONCLUSIONS

In this review it is clear that this species has health benefits. Its possible applications can be found through folk medicine, so it could be a good basis for the start of pharmaceutical developments. Currently, most research focuses on characterizing its essential oil and the presence of nonvolatile compounds. It is a great opportunity to extend its applications, not only in folk medicine, but to other industries. When generating new information in reference to the biology, phytochemistry, pharmacological action and biological activity of the species will allow the species to be incorporated into new products.

The dissemination of good collection practices (Elechosa *et al.*, 2009) and the progressive replacement of the extractive harvesting system with field production (domestication, cultivation and improvement) will guarantee the conservation of genetic diversity and contribute to the sustainable development of regional economies This strategy could ratify the attributes of the final product without damaging the degradation of the biotope, giving time to nature for the renewal this resource (Martínez *et al*., 2000; Martínez *et al*., 2006; Gligo, 2007).

It would be convenient and necessary to implement *ex situ* conservation methods for at-risk species, such as the preservation of biological material in seed banks (local germplasm collections), maintenance of field collections, nurseries and botanical gardens, not only for *H. multiflora*, but also for other species such as*: Minthostachys verticillata, Achyrocline satureoides, Passiflora caerulea, Acantholippia seriphioides, Lippia turbinata and Baccharis crispa* (Barboza *et al.*, 2009). In addition, Elechosa & Juarez (2003) add to this list, *Lippia integrifolia, Baccharis articulata, Baccharis trimera, Satureja odora, Satureja parvifolia, Aloysia citriodora, Aloysia gratissima and Aloysia polystachya*.

In this review, no official regional reports on the supply and demand of this species were found, but it has worked with surveys of collectors and users. There are currently no data on its cultivation, but trials are being developed for its introduction to the field and thus, in the future, to be able to supply the growing market.

Through the implementation of breeding programs, genotypes with different composition of essential oils or other secondary metabolites could be selected, depending on the needs of the producer and the industry. Through the classic improvement or through the application of biotechnological tools, such as those mentioned in this work, the production capacity of the active principles of interest could be increased. New techniques are being developed in other species to obtain cultivars with higher production volumes, with the increase in the amount of secondary metabolites, with promising results (Vazquez *et al.*, 2007). Also, there is progress in the development of *in vitro* propagation protocols in this species and advances in the development of the germplasm of interest.

A greater knowledge of plant genetic resources implies their botanical and cytogenetic characterization, the study of their reproductive behavior and forms of propagation, and in the case of AMPs, the composition of their active principles. Progress has been made on its cytogenetics, this allows contributing to evolutionary and taxonomic studies that can be applied in classical or biotechnological genetic improvement processes.

Although works on its chemical composition have been found, both the studies inherent to the species itself (biology, physiology, phenology), and its biological and medicinal activity, as well as in relation to the physical-environmental and socio-cultural environment in which it is found and used.

In order to meet the objectives of characterization and conservation, it is necessary to have the support of the state in the generation of specific conservation policies for AMPs. In addition, increase control and regulation of the commercial chain. It is also important to establish their genetic diversity, determine their geographical distribution, their uses, and mainly, their level of vulnerability. A state policy that protects genetic resources allows a sustainable use of them, allowing the generation of foreign exchange and jobs to boost regional economies. *Hedeoma multiflora* is a good example to consider as a reference.

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